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CORRELATION OF THE CARBONIFEROUS ROCKS OF NEBRASKA WITH THOSE OF KANSAS

IN THE JOURNAL OF GEOLOGY the writer published in 1897 an article on the "Comparison of the Carboniferous and Permian Formations of Nebraska and Kansas"[1] in which he correlated the formations found in Nemaha, Otoe, and Cass counties of southeastern Nebraska with those of eastern central Kansas. At that time comparatively little work in areal geology had been done in northeastern Kansas, the Cottonwood limestone being the only formation that had been even approximately traced from the Kansas River north to Nebraska.[2]

The correlation of the formations in the above paper was based entirely upon their lithologic, stratigraphic, and faunal characters, for the writer did not have an opportunity to trace the distribution of any of the formations to the north of the Kansas River or to study the geology of the region between that river and Nemaha county, Neb. The rocks to the west of the Missouri River, covering the eastern part of Nemaha, Otoe, and Cass counties, were correlated with the Wabaunsee[3] formation of Kansas; while a massive *Fusulina* limestone west of Auburn, Nemaha county, was regarded as the Cottonwood limestone.

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[1] *Op. cit.*, Vol. V, No. 1, p. 16, and No. 2, p. 148.

[2] See "A reconnoissance geologic map of Kansas," in the Univ. Geol. Surv. Kans., Vol. I, 1896, Pl. XXXI.

[3] Since this article was written a paper has been published by Dr. Charles R. Keyes, in which he substitutes the name "Atchison Shales" for the Wabaunsee formation (Am. Geologist, Vol. XXIII, pp. 304, 309, 310.) The claim for the priority of Atchison shales rests upon the fact that, in 1873, Professor G. C. Broadhead published, under the general title of "Upper Coal Measures," the following heading for a section of the Upper Carboniferous rocks: "General vertical section of Upper Coal Measure rocks below the Atchison county group" (Geol. Surv. Mo., Preliminary Rep. Iron ores and coal fields, 1872, Part II, Geol. Northwestern Mo., chap. iv, p. 88.) In this chapter there is no description of the "Atchison county group" or further reference to it. Chapter xiv of the report by Professor Broadhead is devoted to a description of the geology of Atchison county" (*ibid.*, pp. 376–388); but there is no mention of "Atchison county group" in the entire account, and it is stated under the heading of the "Upper Carboniferous" that "the rocks of this county belong to the

It remained, however, to trace these formations from the Kansas River Valley into Nebraska in order to fully demonstrate the accuracy of the above correlations. Fortunately the recent areal work of the University Geological Survey of Kansas has nearly completed this part of the proof. As the classification of the formations of southeastern Nebraska has an important bearing upon the Permian question of Nebraska and Kansas a synopsis of the results of this work will be of interest. During the summer of 1898, Mr. J. W. Beede of the University of Kansas, traced the Burlingame limestone from the Kansas River,

upper part of the Upper Coal series, and include limestones, sandstones, and shales, amounting to about 180 feet in thickness" (*ibid.*, p. 379). Dr. Keyes gives the thickness of the Atchison shales as 500 feet on the Missouri River, and describes the stage as composed mainly of shales with a stratum of coal near the base (*op. cit.*, p. 310). In Kansas the Wabaunsee formation is composed of massive limestones separated by calcareous, argillaceous, and arenaceous shales. (See the writer's description of the formation in JOUR. GEOL., Vol. III, pp. 688–697.)

The only other reference to the Atchison county group in Professor Broadhead's papers, known to the writer, is in his article on the "Coal Measures of Missouri," where he revised and quoted the section from the 1872 report, with this introductory sentence: "The following is a vertical section of the Coal Measures below the Atchison county beds" (Mo. Geol. Surv., Vol. VIII, 1895, p. 360). On page 377 is a brief description of the highest rocks in the state, which are said to occur in "Atchison and the northern part of Holt county," but as far as a formation name is concerned, they are put under what is termed "Group A," and there is no mention of Atchison county group or beds.

In view of the above facts it does not appear to the writer, in the first place, that the name "Atchison county group," used by Professor Broadhead in 1873, was ever defined as the name of a formation; and, secondly, that the name "Atchison shales," proposed by Dr. Keyes in 1899, is not entitled to be substituted for the Wabaunsee formation described by Prosser in 1895.

The writer finds that the above is essentially the opinion of other geologists familiar with questions of this character. It is clearly stated in the following letter from one of the members of the International Commission on Stratigraphic classification: "I do not possibly see how the use of the term in the manner described could be regarded as a formation name. Many such indefinite uses of local names are found scattered everywhere through geological literature, and if we are to go back in every instance to such a usage, few I fear of our formation names would stand. The name to my mind must be applied to a definite series of deposits with clearly defined limits, if it is to have any formational significance."

near Topeka, to the Nebraska line.[1] The Burlingame limestone was named and described by Mr. Hall, in 1896, from outcrops near Burlingame, Kansas,[2] and since then, through the efforts of Professor Haworth and Messrs. Adams, Bennett, and Beede, its outcrop has been traced[3] from Nebraska across the state to Oklahoma. In its stratigraphic position this limestone is now regarded as forming the basal subdivision of the Wabaunsee formation, which is thus clearly marked, as the limestone forms a prominent escarpment along the greater part of the line of its outcrop across the state. The lower part of the Wabaunsee formation was described from exposures along Mill Creek and the Kansas River between McFarland and Topeka, its base being marked by the Silver Lake coal. At that time the Silver Lake coal, exposed in the Kansas River bluffs west of Topeka, was supposed to belong in the same horizon as the Osage coal and to form a zone capable of being traced for two thirds or more of the distance across the state.[4] Mr. Beede has shown later that the Topeka coal, 125 feet below the Silver Lake coal, is the Osage coal,[5] and since the higher coal is not conspicuous south of the Kansas River it does not serve as a continuous line of division for the base of the Wabaunsee formation. Along the Kansas River, however, the Burlingame limestone[6] is only from 15 to 35 feet above the Silver Lake coal, and as this limestone forms a marked outcrop extending entirely across the state, it serves as a definite line for the base of the Wabaunsee formation, as has been suggested by Professor Haworth.[7]

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[1] Kans. Univ. Quar., Vol. VII, Series A, Oct., 1898, p. 232. A more detailed account will appear in Vol. XVI of the Transactions of the Kansas Academy of Science.

[2] Univ. Geol. Surv. Kans., Vol. I, p. 105.

[3] See "A map showing limestone outcroppings," by ERASMUS HAWORTH, Vol. III, Univ. Geol. Surv. Kans., 1898, Pl. VII.

[4] Jour. Geol., Vol. III, 1895, p. 689 and f. n. 1.

[5] Trans. Kans. Acad. Science, Vol. XV, 1898, p. 30.

[6] MR. BEEDE, in his paper on "The Stratigraphy of Shawnee County" used Swallow's name of Stanton limestone (*ibid*, p. 30).

[7] Univ. Geol. Surv. Kans., Vol. III, p. 105.

As already stated, Mr. Beede has traced the Burlingame limestone from near Topeka to the Nebraska line, where it is, apparently, exposed in the bluff on the northern side of the Great Nemaha River, nearly due north of Robinson, Kansas. At the base of the bluff, several feet below the limestone, coal has been mined which Mr. Beede thinks probably represents the Silver Lake coal, and his description of the stratigraphic position of other coal beds in northeastern Kansas strongly supports this correlation.[1]

On the Kansas River the Wabaunsee formation has a thickness of 500 feet, and this, apparently, agrees quite well with the thickness of the rocks included between the Burlingame limestone in southeastern Nebraska and the limestone west of Auburn, Nemaha county, which is considered to cap the formation and is correlated with the Cottonwood limestone. Mr. Beede states that it is but a short distance east of the exposure of Burlingame limestone and coal in the bluff of the Great Nemaha to the river's mouth, where Hayden saw the outcrop of coal and sandstone on the bank of the Missouri River.[2] This coal, according to Mr. Beede, "is without doubt the same coal that is mined on the north side of the Great Nemaha and, consequently, probably of the same horizon as the Silver Lake coal."[3]

This is an important correlation, for Meek was inclined to consider the outcrop at the mouth of the Great Nemaha as stratigraphically above the famous Nebraska City section, stating that: "I am inclined to believe this sandstone under the coal the same bed seen at Peru and Brownville, and at the base of the section at Aspinwall, though it may be another holding a lower position. If it is the same, there can be little doubt but the exposures here near Rulo hold a position in the series above the horizon of the Nebraska City section."[4] Mr. Beede has also studied the Nebraska City section and, although he has not traced the strata from the mouth of the Great Nemaha to that locality, still he says: "the rocks at Minersville [formerly Otoe City] and Nebraska City are just what we should expect if Meek's correlations were correct, as a comparison will show: At the base of the Nebraska City section are several layers of limestone, then, above, a thick bed of shales and sandstones, coal and limestone, then over 100 feet of shales which contain a second coal, and above this another limestone, which makes it agree in stratigraphic succession, as it does in fossils, with the Topeka section. Thus, considering the great care with which Meek did the work, we can but come to the conclusion that his correlation is probably correct.

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[1] Kans. Univ. Quar., Vol. VII, p. 232, and the forthcoming Vol. XVI, Trans. Kans. Acad. Science.

[2] Final Rep. U. S. Geol. Surv. Nebraska and portions of Adjacent Territories, 1872, pp. 115 and 116.

[3] Trans. Kans. Acad. Science, Vol. XVI.

[4] Final Rep. U. S. Geol. Surv. Nebraska, etc., p. 116.

"If the foregoing statements are correct, we are forced to the conclusion that the Nebraska City section of Meek, from the base of the lower limestone to the top of the Minersville section, corresponds to the Topeka section from the Topeka limestone nearly to the base of the Burlingame limestone."[1] While in another article, in discussing Meek's reference of the sandstone at the mouth of the Great Nemaha to a stratigraphic position above that of the Nebraska City section, he says: "If this be true, it throws the section at Nebraska City in the same general horizon with the Topeka-Osage coal, if it be not identical with it, and the limestone at the base of the section would then represent the Topeka limestone, or a part of it. While I have not been over the ground between Minersville and Rulo, Neb., I am of the opinion that this conclusion is correct."[2]

The writer is inclined to consider the conclusion of Mr. Beede regarding the age of the Nebraska City beds as correct; and if so the rocks composing this section are equivalent to the Topeka limestone and Osage shalesof the Kansas River section, which form the upper part of Professor Haworth's Shawnee formation of the Upper Coal Measures.[3] This correlation agrees quite closely with my earlier one, for it was stated in that paper that: "The writer is not confident whether the Nebraska City beds should be referred to the upper part of the Missouri formation,[1] or to the Wabaunsee formation of the Missourian series. However, the faunal and lithologic characters of the beds near Nebraska City agree quite closely with those of the lower half of the Wabaunsee formation as shown along the Kansas River above Topeka, and so the writer refers them provisionally to it."[2]

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[1] Trans. Kans. Acad. Science, Vol. XVI.

[2] Kans. Univ. Quar., Vol. VII, Ser. A, pp. 232, 233.

[3] Univ. Geol. Surv. Kans. Vol. III. p. 94.

The distribution of the carboniferous rocks in southeastern Nebraska has been given by Mr. N. H. Darton, on a "Preliminary Geologic Map of Nebraska,"[3] where they are represented under the legend of the "Cottonwood and Wabaunsee formations." On the same map, a part, at least, of the rocks mapped in the Big Blue valley as "Permian limestone" may be correlated with the Chase formation of Kansas.

It will be remembered that Marcou referred the Nebraska City beds to the Permian, and in this correlation he was supported by Geinitz, who described the fossils collected by Marcou, and strongly opposed by Meek, who referred the rocks to the Upper Coal Measures. This difference of opinion led to a sharp controversy, the essential features of which were noted in my former paper.[4] There is now no question but that Meek was correct in referring these rocks to the Coal Measures, as was noted in the writer's former paper, and is now stated by Mr. Beede.

It seems important, however, to again call attention to the fact that Meek in correlating these rocks along the Missouri River in southeastern Nebraska with the Upper Coal Measures did not intend to include the rocks in Kansas which he and Hayden had called Permian,[1] a fact which has been overlooked by some of the later writers in considering the rocks of this region or the Permian. This was stated clearly enough by Meek when he gave his views regarding the age of these rocks as follows: "[they] really belong entirely to the true Coal Measures; unless the division C [the upper fossiliferous one] at Nebraska City, and some apparently higher beds below there on the Missouri, may possibly belong to the horizon of an intermediate series between the Permian and Carboniferous, for which, in Kansas, Dr. Hayden and the writer proposed the name Permo-Carboniferous . . . . . It is true that in first announcing the existence of Permian rocks in Kansas, we also, upon the evidence of a few fossils from near Otoe and Nebraska Cities, resembling Permian forms, referred these beds to the Permian; but on afterwards finding that these fossils are there directly associated with a great preponderance of unquestionable Carboniferous species; and that there is also in Kansas a considerable thickness of rocks between the Permian and upper Coal Measures containing, along with comparatively few Permian types, numerous unmistakable Carboniferous forms, we abandoned the idea of including these Otoe and Nebraska City beds in the Permian. And all subsequent investigations have but served to convince us of the accuracy of the latter conclusion."[2] This view was explained more fully in Meek's Review of Geinitz, on the rocks and fossils of Nebraska, published in the November following his exploration there, in which, after describing a series of rocks occurring in Kansas, containing an extensive Coal Measure fauna, often mingled in the same beds with a few Permian types, he said: "In ascending several hundred feet higher in the series, we observed the Coal Measure forms gradually dropping off until at last, above a certain undefined horizon, with the exception of one or two of the latter, only Permian forms were observed. Although we regarded these upper beds as the true representatives of the Permian, we gave a section of the whole series, down so as to include a considerable thickness of beds below, with lists of fossils, showing the range of the various types, without drawing any line of demarkation, because we were satisfied nature had nowhere defined any abrupt physical or paleontological break here in the series,"[1] . . . . that is, that there is in this region [Kansas], a gradual shading off from an upper Coal Measure to a Permian fauna, through a considerable thickness of strata, forming a somewhat intermediate group, which we called the Permo-Carboniferous series ; also that there is no defined break between this intermediate series and the Permian above, or the Coal Measures below."[2]

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[1] At the time the above article was written I understood that Dr. Keyes intended to retain the above name for that division of the Missourian series next older than the Wabaunsee formation. It was not used, however, and now Professor Haworth's Shawnee formation includes that part of the series.

[2] JOUR. GEOL., Vol. V, p. 151.

[3] Nineteenth Ann. Rep, U. S. Geol. Surv., Pt. IV, Pl. LXXXII.

[4] *Op. cit.*, pp. 12–16.

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[1] Trans. Albany Inst., Vol. IV, 1858, p. 76; Proc. Acad. Sci. Phil., Vol. XI, 1859, pp. 20. 21; and Am. Jour. Sci., 2d ser., Vol. XLIV, 1867, p. 37.

[2] Final Rep. U. S. Geol. Surv. Neb. etc., pp. 130, 131.

It is also true that Hayden did not abandon the correlation of the highest Paleozoic rocks of Kansas with the Permian, for in July, 1867, he published some "Notes on the Geology of Kansas," in which he reviewed "Swallow's Preliminary Report of the Geological Survey of Kansas," not accepting his division of the Lower Permian as of true Permian age, and said: "As we ascend in the series, we find that, after going some distance above the supposed line of demarcation [Swallow's between the Lower Permian and Coal Measures] the Carboniferous species gradually begin to disappear, and the Permian types become rather more common, in particular beds, until we have ascended to a point near the horizon Professor Swallow makes the line between the Upper and Lower Permian, when we find we have almost completely lost sight of the familiar Carboniferous species, a few of which had continued on up to near this point, and see scarcely any but forms such as in Europe would be regarded as Permian types. There is no physical break here, however, nor *abrupt* change of fossils. Hence Meek and Hayden regarded the beds below the horizon down so far as to include most, if not nearly all, of Professor Swallow's Lower

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[1] Am. Jour. Sci. 2d ser. Vol. XLIV, 1867, p. 334.

[2] *Ibid*, pp. 338–339.

Permian, as an intermediate connecting series between the Permian and Coal Measures which, if worthy of a distinct name at all from the latter, should be called Permo-Carboniferous, while the beds above they regarded alone as properly the equivalent of the true Permian of Europe.

The occurrence of a few types that would generally be regarded as Permian, along with numerous well-known Coal Measure species, far below the true Permian, only accords with facts observed in other formations in this country, where certain types evidently made their appearance here long before they are known to have appeared in Europe."[1] In discussing the rocks of Gage county, Nebraska, in the Final Report of 1872, Hayden also described a section on a small branch of the Big Blue River, near Beatrice, about which he wrote as follows: "Beds 1, 2, and 3 of the above section are undoubtedly of Permian or Permo-Carboniferous age, though they contain fossils common to both Permian and Carboniferous rocks. . . . . Bed 4 seems to form a sort of transition bed between the Permian[2] and Carboniferous [misprint for Cretaceous] formations."[3]

This later study of the rocks of southeastern Nebraska has made it possible for us to determine approximately how far below the base of Meek and Hayden's Kansas Permian the Nebraska City rocks occur, and this is perhaps its most important result. The line between the Permian and Permo-Carboniferous of Meek and Hayden was drawn at the top of No. 11 of their "General section of the rocks of [the] Kansas Valley;"[4] which, as I have shown, occurs about ninety feet below the top of the Chase formation.[5] Then, if we accept the correlation that the top of the Minersville-Nebraska City section is stratigraphically a little lower than the Burlingame limestone, we will find that on the Kansas River, between the base of this limestone and that of Meek and Hayden's Permian are the Wabaunsee, Cottonwood, and Neosho formations, together with the greater part of the Chase formation, having a total thickness of approximately 900 feet. When it is also considered that massive limestones constitute a considerable portion of these rocks it will be seen that there is a decided time interval between the Nebraska City rocks and those of Meek and Hayden's Permian in Kansas. Or, again, the thickness of the rocks between the base of the Burlingame limestone and the base of Swallow's Lower Permian along the Kansas River, or Meek and Hayden's Permo-Carboniferous, is approximately 525 feet.

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[1] *Ibid.*, p. 37. In this paper Hayden referred to notes which Meek had given him, stating that they "form the substance of this article," p. 321.

[2] It is not certain that the true Permian beds, as recognized in Kansas, extend northward into Nebraska, though thin beds may occur in some of the southern counties.

[3] Final Rep. U. S. Geol. Surv. Nebraska, etc., p. 28.

[4] Proc. Acad. Nat. Sci. Phil., Vol. XI, 1859, pp. 16 and 20.

[5] JOUR. GEOL., Vol. III, pp. 784, 797, 798.

The failure to note the difference in age and faunas between the rocks of the Nebraska City region, along the Missouri River, and those of the upper Kansas and lower Smoky Hill River valleys in Kansas has led to certain erroneous statements and conclusions. This is possibly the explanation for the statement of Professor Calvin in his contribution to "A symposium on the classification and nomenclature of geologic time-divisions," in which he says: "The greater part of the assemblage of strata called Permian by Prosser and the geologists of Kansas University contains precisely the same fauna as our Missourian or Upper Coal Measures, and if there is no better excuse for recognizing Permian in America than that afforded by the beds in question, then America has no Permian."[1] The rocks which I have correlated as Permian, but without expressing a positive opinion as to whether the division should rank as a distinct system or as the upper group of the Carboniferous system (using Dana's stratigraphic terms) are the Neosho, Chase, Marion, and Wellington formations and the Cimarron group or Red-beds. The line between the Permian and the Upper Coal Measures or Missourian group was drawn provisionally at the base of the Neosho formation;[2] because in the Neosho and

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[1] JOUR. GEOL., Vol. VI, p. 353.

[2] *Ibid.*, Vol. III, pp. 795, 800.

Chase formations zones occur in which there are numerous specimens of a few species which belong to genera that in Europe are regarded as of Permian age; but inter-stratified with these zones are others which contain numerous specimens of a considerable number of the Missourian species. The writer has already stated that "The Neosho and Chase formations are transitional from the Upper Coal Measures to the Permian as first defined by Murchison for Russia, and belong to the division which has generally been called Permo-Carboniferous in this country. In accordance with the views of the majority of present European geologists familiar with this problem it is probably better to include the Permo-Carboniferous rocks of Kansas in the Permian series."[1] The base of the Neosho formation is about 50 feet higher than the base of Swallow's Lower Permian or Meek and Hayden's Permo-Carboniferous; and the top of the Chase formation is, approximately, 90 feet higher than the base of Meek and Hayden's Permian, or between 50 and 80 feet lower than the top of Swallow's Lower Permian. The thickness of the Neosho is 130 feet,[2] and that of the Chase 265 feet,[3] making a total thickness of 395 feet. Mr. Beede, who is describing the Carboniferous and Permian invertebrate faunas for the University Geological Survey of Kansas, writes me that "there is ample evidence for placing the division line between the Coal Measures and Permian where you have."

Succeeding the Chase is the Marion formation, with a thickness of from 300 to 400 feet.[4] The lower portion of the Marion contains a fair Lamellibranch fauna which, however, decreases until in its upper part very few species are found. The following thirteen species and one variety have been found in this formation, together with some other forms which as yet have only been doubtfully identified either specifically or generically, viz.: *Aviculopecten occidentalis* (Shum.) Meek, *Bakevellia parva* M. &

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[1] JOUR. GEOL., Vol. III, pp. 795, 796.

[2] *Ibid.*, pp. 766, 799.

[3] *Ibid.*, pp. 773, 798.

[4] Univ. Geol. Surv. Kans., Vol. II, p. 66.

H., *Myalina perattenuata* M. & H., *M. permiana* (Swallow) M. & H., *Nautilus eccentricus* M. & H., *Nuculana bellistriata* Stevens var. *attenuata* Meek, *Pleurophorus Calhouni* M. & H., *P. subcostatus* M. & W., *P. subcuneatus* M. & H., *Pseudomonotis Hawni* (M. & H.) sp., *P. Hawni* (M. & H.) sp. var. *ovata* M. & H., *Schizodus curtus* M. & W., *S. ovatus* M. & H., and *Yoldia subscitula* M. & H.

All of the species are Lamellibranchs with the exception of the *Nautilus* which is a Cephalopod. One species begins in the Lower Coal Measures; another is first reported from the Des Moines of Iowa and then from the Kansas Permian, not appearing in the interval; six appear in the Upper Coal Measures and the remaining six are known only in rocks of the age of Meek and Hayden's Kansas Permian, with one exception, which is reported from the Permo-Carboniferous of Utah and from rocks in New Mexico referred doubtfully to the Upper Coal Measures.

The abundant species and about the only ones found in the upper part of the formation are:

1. *Bakevellia parva* M. & H. — Permian of Kansas (in each instance meaning that division of Meek and Hayden), and from Arizona in rocks stated by Dr. White to probably belong in the Permian, while he found a closely related form in New Mexico "at the summit of the Carboniferous series" (U. S. Geog. Surv. W. 100 Merid., Vol. IV, p. 153). This species is closely related to *B. antiqua* Münster, which is common in the Permian of England, Germany, and Russia.

2. *Myalina permiana* (Swallow) M. & H. — Permian of Kansas and Texas. Reported by Hall & Whitfield from the Permo-Carboniferous of Utah; and by Dr. White from New Mexico in rocks which were referred doubtfully to the Upper Coal Measures.

3. *Pleurophorus subcuneatus* M. & H. — Permian of Kansas; Dr. Keyes reports: "There is but little doubt that the form from Des Moines [Lower Coal Measure of Iowa] is identical with that figured by Geinitz in 1866 as *Pleurophorus simplus* of Keyserling" (Proc. Acad. Nat. Sci., Phil., 1891, p. 250) There is no other record, however, of the occurrence of this species until Meek and Hayden's Permian is reached in Kansas, and Mr. Beede informs me that he has not seen it below the Permian there. This species is so nearly related to the *P. simplus* v. Keys. sp. of the Russian Permian that Geinitz regarded them as identical.

4. *Pseudomonotis Hawni* (M. & H.) sp. — Permian of Kansas. Heilprin

reported from the Upper Coal Measures of Pennsylvania "an obscure impression which may be that of this species, but very doubtful" (Second Geol. Surv. Pa., Ann. Rep., 1885, p. 455). Mr. Beede writes me, however, that it begins near the base of the Upper Coal Measures of Kansas, and he will shortly publish an article describing the Kansas species of this genus. This species was regarded by Swallow and Geinitz as identical with *P. speluncaria* Schloth. sp., which is a common Permian form in England and Germany.

5. *Myalina perattenuata* M. & H. also occurs near the top of the Marion and is reported from the Permian of Kansas and Texas, and the Upper Coal Measures of Missouri and Illinois.

The only Brachiopods found are specimens of *Derbya* from the lower part of the formation, which are doubtfully referred to the species *D. multistriata* M. & H. sp., which occurs in their Kansas Permo-Carboniferous. The disappearance of the Brachiopods was perhaps due in part to the diminished depth of the water, but in a much greater degree, undoubtedly, to the highly concentrated nature of the waters, as shown by the deposits of rock salt and gypsum. This change in the condition of the water affected the other forms of life unfavorably; but there remained, as we have seen, a meager Lamellibranch fauna which differed decidedly from the Lamellibranch fauna of the Coal Measures and is closely allied with the Permian Lamellibranch fauna of Europe.

The Wellington formation succeeds the Marion, varying in thickness from about 200 feet on the Smoky Hill River to 450 feet in Sumner county, near the southern line of the state,[1] in which, as far as known to the writer, no fossils have yet been found.

The Paleozoic of Kansas closes with the Cimarron group or the Red-beds, which in the southern part of the state are from 1150 to 1400 feet thick.[2] The absence of fossils has formerly made the correlation of this group rather indefinite. Professor Cragin has compared the stratigraphy of the Red-beds of the Kansas-Oklahoma basin with those of northern Texas and stated that the gypsum beds of the Cave Creek formation, the top of which is about 250 feet below the summit of the Kansas Red-beds, apparently connect them "by a bond of stratigraphic continuity with the demonstrated Permian of Texas."[1]

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[1] Univ. Geol. Surv. Kans., Vol. II, p. 67.

[2] *Ibid.*, p. 88.

Fossils have recently been found about 100 feet above the base of the Cimarron group in the northern part of Oklahoma. The most abundant specimens are species of a Phyllopod Crustacean which unfortunately were poorly preserved and, therefore, identified with some doubt by Professor T. Rupert Jones as *Estheria minuta* Alberti sp.[2] This species is characteristic of the Triassic in England, France, and Germany, apparently occurring most abundantly in the Keuper of the Upper Triassic.

Associated with the Crustacean fossils was the greater part of the skeleton of an Amphibian which has been identified by Professor Williston "as *Eryops megacephalus* Cope, a form described from the 'Permian' of Texas." Professor Williston, in discussing the importance of this discovery in reference to the age of the Red-beds, says: "This identification settles once for all the horizon whence it came as Permian, if the Texas beds be really of that age. There are several hundred feet of deposits in Kansas above this horizon that still possibly may be considered as Triassic, but there is no reason for so doing. *Estheria minuta* is a Triassic species, but, even if correctly determined, its value is slight in comparison with that of the vertebrate in the correlation of the beds. It must be remembered, however, that *Eryops* is by no means necessarily characteristic of the Permian."[3]

Professor Williston has written me as follows regarding Cope's correlation of the Texas deposits with the Permian: "In his first work upon the Texas beds Cope determined them as Triassic, and he seems never wholly to have overcome the idea that they may not be of Triassic age, but in all his later papers upon the forms he refers to the beds as Permian. I suppose the reason for this collocation is the fact that the nearest related forms are found in the European Permian. Thus, *Euchirosaurus* and *Actinodon* are referred to the lower Permian in France (the Rothliegenden of Autun). I at first thought that the present form might be *Actinodon*, but the bones made out agree quite closely with the figures of *Eryops megacephalus* given by Cope."[1]

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[1] Colorado College Studies, Vol. VI, p. 5; see also pp. 2, 3, 30, 48. The correlation of the Red-beds from this stratigraphic evidence was discussed by the writer in the Univ. Geol. Surv. Kans., Vol. II, pp. 89–92.

[2] Geol. Mag., Dec. IV, 1898, Vol. V, p. 292.

[3] Science, N. S., Vol. IX, Feb. 10, 1899, p. 221.

The above brief summary of the Permian rocks of Kansas shows that fossils occur in beds varying in thickness from 1000 to 1350 feet; while if all of the Red-beds are of the same general age, as is possible, the estimated total thickness of the Permian would then range from 2050 to 2650 feet. The majority of the species found in the lower 400 feet, the Permo-Carboniferous deposits, occur in the Upper Coal Measures (Missourian), and perhaps one half of the species in the succeeding 300 or 400 feet; but above that horizon none have been found which are even closely related to those in the Coal Measures. On the contrary, this higher fauna seems to be as nearly related to the Triassic as to the Carboniferous. This would seem to be sufficient proof that the greater part of Permian strata does not contain "precisely the same fauna as our Missourian or Upper Coal Measures," since only the lower 400 feet of deposits, ranging in thickness from 1350 to perhaps 2650 feet, contain a fauna composed largely of species which occur in the Upper Coal Measures. These lower beds are transitional, but this fact does not seem to the writer to furnish sufficient proof that the higher ones at least are not of Permian age.

CHARLES S. PROSSER.

UNION COLLEGE,
March 1899.

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[1] Letter of Feb. 26, 1899.